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ABSTRACT

Noting that although a great deal of empirical research has been done to investigate the writing rules commonly taught, this paper points out that no one has yet constructed a deep theory of the relationship between cognition and writing that confirms the writing rules and explains how they work. The paper then uses theories and research in the fields of cognitive psychology, social psychology, philosophy of language, information theory, reading theory, rhetoric, and systems theory to construct a deep theory of the relationship between language, cognition, and writing. Concluding from this research that language and cognition are independent of one another, the authors argue that language has meaning when it produces abstract, holistic throughts in the person using it; and that it is a tool for representing abstract cognitions to oneself and for communicating them to others. It then builds a theory of writing containing 15 definitions, 11 premises, and 11 principles, the latter of which (the principles) subsume practical writing rules, especially those of science writing, and offer a broad framework for research. The paper concludes by presenting the results of several exploratory studies that have used R. F. Carter's signaled stopping technique as a means of observing the cognitive effects of writing. (Author/FL)

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AN AXIOMATIC THEORY OF COGNITION AND WRITING

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AN AXIOMATIC THEORY OF COGNITION AND WRITING

Abstract

A great deal of empirical research has been done in the past to test writing rules commonly taught in the classroom. To date, however, no one has constructed a deep theory of the relation between cognition and writing that confirms the writing rules and explains why they work. In this paper, the authors attempt to construct a deep theory of the relationship between language, cognition, and writing--based upon theories and research in the fields of cognitive psychology, social psychology, philosophy of language, information theory, reading theory, rhetoric, and systems theory.

Research in these fields shows that language and cognition are independent of one another. Language has meaning when it produces abstract, holistic thoughts in the person using it. Language is a tool used for representing abstract cognitions to oneself and for communicating them to others. As a tool, however, language bears a strong resemblance to the cognitions it represents.

Working from these basic presuppositions, the authors build a theory of writing that contains 15 definitions, 11 premises, and 11 principles. The 11 axiomatic principles subsume practical writing rules, especially science writing rules, and offer a broad framework for research. The authors conclude the paper by presenting the results of several exploratory studies that have used Carter's signaled stopping technique as a means of observing the cognitive effects of writing.

AN AXIOMATIC THEORY OF COGNITION AND WRITING

Nearly 20 years ago, the senior author of this paper was surprised one evening when the instructor of a graduate seminar in writing reseach handed out a page of 'untested writing advice.' The handout contained such advice as 'use the active voice' and 'use simple rather than complex sentences.' Most of this untested advice consisted of writing rules that are taught as givens in writing courses. The idea that rules of writing style and organization can be submitted to scientific scrutiny probably also would shock most writing teachers. Most consider writing to be an art and not a science; most do not believe the effects of following writing rules can measured and evaluated.

A great deal of empirical research has been done on writing rules, and the research generally has confirmed that the rules work--that is, people comprehend or understand what they read more often when the writer has used the active voice, familiar words, analogies and examples, and similar stylistic devices.(1) Writing researchers today, however, face a task much more formidable than developing empirical tests of writing rules. They must develop what philosophers of science call a 'deep theory' of language and writing that can explain the results of the numerous low-level empirical studies of writing rules and explain why those writing rules work.(2)

In 1980, Grunig reviewed research on communication of scientific information to nonscientists and used a situational theory of communication behavior to integrate the low-level empirical studies he reviewed.(1) He concluded that his theory was a deep theory to

the extent that it could explain when and how scientists, science writers, editors, public relations writers, and science audiences communicate individually and with each other. But he also concluded that his behavioral theory could not explain how writing should be done to help readers gain maximum understanding of difficult scientific concepts.

In this paper, we will develop a theory of cognition and writing that we believe is capable of providing that missing language link in Grunig's theory of science communication. The theory we develop is a language theory, with concepts taken from cognitive psychology, social psychology, philosophy of language, information theory, reading theory, and rhetoric. As a language theory, it should be immensely useful to writing teachers, because it subsumes the myriad writing rules taught to students into 11 axiomatic principles of writing.

We will present the results of exploratory experimental studies that we have conducted to test the axiomatic principles of the theory. However, these principles are largely underdetermined by data, which Suppe, a philosopher of science, has said is typical of a deep theory.(3) Thus, the 11 axiomatic principles should also stimulate additional scientific research on writing to provide further evidence to support, revise, or reject them.

Although this language theory applies to different phenomena than does Grunig's situational theory of communication behavior--cognitions rather than communication behavior--it is based on the same assumptions as that theory. As a result, it should make a marriage of language and communication theory possible. Such a marriage is important, for as Arundale has pointed out, few lang-

uage theorists have recognized that 'humans use language in communication situations.'(4) Rather they have theorized more about the structure of language and how humans process language than on how people use language to communicate with each other.

ROOTS OF THE AXIOMATIC THEORY

For centuries, four questions have troubled theorists in several disciplines in the social sciences and humanities:

*What is an idea or thought?

*What is the nature of language?

*What is the relationship between language and thought?

*What is the meaning of meaning?

The answers to those questions have changed considerably over the years. More than 2,500 years ago, Aristotle believed that categories of thought determined categories of language. In the 1930s, the behavioral psychologist John B. Watson argued that language and thought were identical, that thought was no more than subvocal speech.(5) Perhaps the best-known theory of language and thought is the linguistic relativity hypothesis--also known as the Whorf-Sapir hypothesis after Edward Sapir and Benjamin Whorf who developed it.(6) Although Whorf and Sapir did not argue that language and thought were identical, they did argue that language determines thought--that people cannot think except in the categories found in their language. For example, English-speaking people have difficulty thinking like Eskimos, who have many different words for snow, or like Arabs, who have 6,000 different ways of naming camels.

Although there is no consensus on these questions at present, theorists in most language disciplines generally answer the four

questions above in these ways:

*A thought is an abstract relationship that is independent of language.

*Language is a tool used for representing thoughts to onself and for communicating them to other people. Language and thought, however, are independent of one another.

*Just as tools are designed to fit the objects upon which they are used, so language has developed to fit the kinds of thoughts it represents and communicates.

*Language has meaning when it produces an abstract, holistic idea in the person using it. Meaning is not to be found in the referents of individual words, phrases, or sentences.

With these answers to the four classic questions in mind, the basic theme of a theory of writing should be clear. Writing is a tool people use to communicate ideas to others--and sometimes to organize their own ideas. Writing is more of a cognitive process than a linguistic process. A theory of writing, therefore, must explain how writers should choose words, or other symbols, to best communicate abstract ideas to themselves or to other people--i.e., instructions on how best to use the tool of writing to accomplish its purpose, the shaping or communication of ideas.

In developing our axiomatic theory of language, we examined the theories and research on language in several social science and humanistic disciplines. We will briefly review these theoretical traditions to show the sources of the concepts in our theory. We begin with the oldest theoretical tradition, the philosophy of language.

Philosophy of Language

Philosophers have reflected intensively on the four questions listed above, asking 'what is meaning,' 'what must the human mind be like to have learned rules and principles of grammar,' 'is it possible to lend any order and system into the multiplicity of functions that language can perform.'(7)

Six different theoretical traditions have developed in philosophy of language, culminating with the 'use tradition' that we have incorporated into our axiomatic theory:(8; 7, p. 14; 9)

*A behavioral tradition presupposed that the meaning of language is in the behavioral responses that it produces in people.

*A referential tradition presupposed that words or symbols represent concrete objects in the external world.

*An ideational tradition--originated by John Locke--presupposed that language represents mental ideas or images.

*A use tradition assumes that the meaning of language lies in the uses to which people put it.

*A phenomenological tradition views language not as a tool to represent or describe reality, but as a system in use that creates reality in the mind of a person and creates the person himself.

*A sixth tradition, reflecting Marxist thought, sees humans as creations of their culture and of the structures of situations of which they are a part. In this view, situations determine human behavior, and language is the device people use to 'read' these situations and to develop a socially based self-identity.

Philosophers appear to have moved toward a consensus around the use theory or the phenomenological or Marxist variations of that theory. The most widely accepted philosophical theory of

language is based on Wittgenstein's ordinary language philosophy--that the meaning of words can be found in a painstaking analysis of the ways in which people use them in ordinary life--and Austin's concepts of speech acts.(10, 11) Austin distinguished between illocutionary acts (the acts that people perform with the aid of words and sentences, acts such as telling, reporting, questioning, or stating) and perlocutionary acts--the consequences of illocutionary acts (to say something that persuades, amuses, irritates, deceives, etc.)(12)

Language is an instrument that can be used to perform illocutionary acts. Meaning is the 'force of an illocutionary act,' the range of acts that an expression can perform.(7, pp. 203-208) Illocutionary expressions have meaning because of the rules and conventions that govern their use. Perlocutions, however, are not rule-governed; different perlocutionary acts frequently result from the same illocutionary act.

The distinction between illocutionary acts and perlocutionary acts constitutes an important distinction in our axiomatic theory. We define communication as the performance of an illocutionary act and argue that persuasion (a perlocutionary act) is a secondary effect of communication--in contrast to many communication theories that argue that communication must be persuasive for it to be effective.

Philosophers of language generally reject the notion that language determines thought and accept the view that cognition and language are independent. But they argue that a person cannot have access to cognitions without language. In Hartnack's words, 'It is impossible to think, to believe, to act, or to be conscious without

a language...(but this) does not imply that thinking, believing, acting, and being conscious are identical to language."(13) What is important to the philosopher, therefore, is the care with which people use language to perform illocutionary arts, for the choice of an incorrect word, phrase, or sentence could confuse cognition or communication.

Language psychologists, as we will see next, have similar theories of language; although they generally conceptualize a greater separation between thought and language than do philosophers.

Psychology of Language

Language psychology is also known as psycholinguistics because it sometimes combines theories from psychology and linguistics, a tradition that began in 1951 when three linguists and three psychologists participated in a summer seminar at Cornell University sponsored by the Social Science Research Council.(14) Psycholinguistic research burgeoned, however, after psychologist George Miller introduced the theories of linguist Noam Chomsky to psychologists in 1962.(15)

Theories of language psychology fit into traditions that are similar to those in the philosophy of language:

*The earliest tradition was the behavioral tradition, characterized by the work of B. F. Skinner, which presupposed that all language is learned by trial, error, and reinforcement.(16)

*Other behavioral psychologists, such as Osgood (17) and Staats (18), developed a softer behavioral theory--the mediational approach--in which they argued that people learn language initially by trial and reinforcement, but that once learned, language media-

tes their learning of additional language.

*A third tradition, based on Chomsky's theories (19), presupposed that language competence stems from an innate language acquisition device that is independent of cognitive development and ability. Chomsky argued that children could not possibly learn the complexities of language as quickly as they do simply by behavioral trial and error. Instead, he argued, they must possess innate language universals that manifest themselves rapidly as children learn language. Chomsky's key contention was that language and cognition develop as independent systems subject to different laws, a contention that psychological research generally has not supported.(5, pp. 367-399) Chomskyans have been relatively successful in explaining why people use the syntax they do; they have not been successful in explaining the semantive of language--why it has meaning.

*As Chomsky's influence on psycholinguistics ran its course, language psychologists turned to an information-processing approach to examine how people recognize and attach meaning to words, sentences, and larger language units, an approach that reflects the concerns of cognitive psychology rather than linguistics.(20) Thus, theories of cognitive psychology have assumed new importance in the psychology of language, as they have in many areas of psychology.(21) Now, this micro-level approach is giving way to a more holistic perspective, which presupposes that language has meaning when a person can use it to produce an abstract idea and not because a person can remember or react to specific words and sentences. Today, cognitive psychologists generally believe language development reflects the stages of cognitive development--such as

those proposed by the Swiss psychologist Piaget--and that it does not reflect the presence of an innate language acquisition device.(22)

Language psychologists following this latest theoretical tradition have researched the speech sound system, the syntax of language, and the meaning of language. Of these research problems, the problem of meaning has been most difficult to solve.(22) Yet, it is the central problem for a theory of cognition and writing that should specify how writers should write so that others can understand the meaning of their writing.

Language psychologists have learned how people remember words, sentences, and larger units of language. But they have found that the sum of the parts does not equal the whole. People remember more than language; they remember the ideas that the language expresses.(5, pp. 384-387; 24) Cognitive psychologists now believe that thought exists independently of language and that thought can occur before and without language. They believe that people use language appropriate for their stage of cognitive development or language appropriate for a particular cognition. And they have found that language becomes more complex as cognitive structures become more complex--a relationship that is extremely important for understanding the differences between the languages of scientists and nonscientists.

Anderson elaborated on these new cognitive theories as follows:

> There are numerous reasons to suppose that the human's ability to think (that is, to engage in nonlinguistic cognitive activity such as remembering and problem solving) appeared earlier evolutionarily and occurs sooner developmentally than the ability to use language. Many species of animals without language appear to be capable of a complex cognition. Children, before they are effective at using

> their language, give clear evidence of relatively complex cognition. If one accepts that thought occurred before language, it seems natural to suppose that language is a tool whose function is to communicate thought. It is generally true that tools are shaped to fit the objects on which they must operate. Analogously, it seems reasonable to suppose that language has been shaped to fit the thoughts it must communicate.(5, p. 387)

Psychological studies of bilinguals provide additional evidence that thoughts occur independently of language. That research shows that bilinguals have a single conceptual system that is common to both languages; they do not think differently when they switch from one language to another.(22, p. 189)

Anderson illustrated how language is shaped to thought by pointing out that in 98 percent of the languages in the world the subject always precedes the object.(5, p. 388). 'This order makes good sense,' he explained, 'when we think about cognition. An action starts with the agent and then affects the object. Therefore, it is natural that the subject of a sentence, when it reflects its agency, occurs first.'

Once psychologists decided that ideas occur in something other than language, their task was to construct a theoretical representation of ideas. As we saw above, language philosophers rejected John Locke's theory that ideas consist of visual images that are accessible through introspection. Psychologists, too, have rejected that interpretation. Although they believe that people do have mental images, psychologists believe that images, like words, are connected to more abstract 'cognitive structures' that are less subject to introspection.

According to Anderson, cognitive psychologists now use propositional networks to describe how meaning occurs in memory. Propositional networks link several propositions; a proposition is 'the

smallest unit of knowledge that can stand as a separate assertion."(5, p. 101) For example, the sentence "Nixon gave a beautiful Cadillac to Brezhnev, who is leader of the USSR," contains three propositions:

1. Nixon gave a Cadillac to Brezhnev.
2. The Cadillac was beautiful.
3. Brezhnev is leader of the USSR.

Anderson's research has shown that experimental subjects remember these propositions, although they do not remember the exact wording of the sentences.(5, p. 102) People retain the meaning of words and sentences as configurations or networks of propositions, which Anderson describes as "a tangle of marbles connected by strings. The marbles represent the nodes, and the strings represent the links between the nodes."(5, p. 103) There may be several kinds of links, including subject, object, relation, agent, recipient, and time links.

Other cognitive psychologists and communication scientists have developed similar models of cognitive structures. Communication theorists Woelfel and Fink have described cognitions as the relationships between concepts.(25) Their "concepts" resemble the nodes of Anderson's "propositions;" a "20 percent tuition increase" is an example of a concept in the mid of a university student.(26) In contrast to Anderson's relatively inflexible strings, however, Kaplowitz and Fink described the relationships between concepts as springs, which stretch back and forth.

Other theorists have depicted cognitive structures as relationships between objects and attributes--e.g., communication theorist Richard Carter described several kinds of object-attribute

"pictures," including:(27)

*Objects or attributes that include or exclude another object of attributes.

*Objects or attributes with a spatial relationship.

*Objects and attributes linked by time.

*Objects or attributes that are functionally related--one helps to bring about the other.

*Objects or attributes that are necessary or sufficient for the occurrence of other objects or attributes.

Psychologists Scott, Osgood, and Peterson also chose an "object-attribute conception...as only one of many possible ways of characterizing an individual's view of the world."(28) They added that the object-attribute conception is "an appropriate formulation for many kinds of cognition, but quite awkward for others. Similarly, psychologists Horton and Turnage stated that a concept has "two critical features":

> (1) the set of relevant attributes that specify the stimulus characteristics of the concept, and (2) the rule that defines the relationship between the relevant attributes. Together, the relevant attributes and the rule serve to define the concept.(29)

These models of ideas are similar to each other. In general, they suggest that cognitive structures consist of one or more of the following: (1) subjects or agents, objects, attributes or characteristics, recipients of actions and (2) relations or rules that bind these objects, attributes, agents and recipients together, such as spatial, time, or logical connections.

At some time, it may be useful to develop a taxonomy of cognitive structures, from which writers could choose an appropriate structure for organizing their thoughts before they begin to write.

Or a science writer, for example, could match a scientist's theory with one of the cognitive structures in the taxonomy and decide whether that structure is too difficult for the reader to understand. If readers can understand the scientist's cognition, writers could use that cognitive structure as a model to organize their writing. If the cognition is too difficult, science writers would have to rearrange it into a simpler cognitive structure--using analogies or metaphors, for example--before using the structure to model their writing.

A great deal of theoretical work must be done, however, before such a taxonomy is available. In the meantime, we can construct a writing theory that includes the assumption that cognitions must be structured--organized through what writing teachers call 'prewriting'--before writing based on that structure can be meaningful to a reader.(5, p. 454.) Research shows that people remember better what they read when a text is structured.(5, pp. 423-426) We do not assume, however, that writers will always have a well-ordered cognition before they begin writing. As experienced writers know, the writing process often is an effective way of forcing writers to organize and structure their ideas.(30) We can also assume that cognitive structures vary in complexity and that 'simplified writing' alone cannot make the complex cognitive structures of scientists meaningful to nonscientists.

Before leaving psychology of language, however, we turn to three other concepts that are important to our axiomatic theory.

The first of these is the cognitive psychologist's concept of memory.(28, pp. 151-188; 5, pp. 163-191) Cognitive psychologists conceptualize memory as having three components:

*Sensory memory, which preserves sounds and visual images for a few seconds.

*Short-term memory, which allows people to keep information in a special active state but which has limited capacity--seven plus or minus two bits of information.(31)

*Long-term memory, which has infinite capacity to hold information but whose holdings are not accessible to people unless they can bring the information back into short-term memory.

Because of the limited capacity of short-term memory, information must be chunked or structured before it can pass into long-term memory--where it is retained in propositional form. In turn, people cannot access information stored in long-term memory without bringing it out in chunks. Horton says that research suggests that the memory system is a multiprocess system rather than a dual system but that people process informa ion into memory and access it in stages that resemble the concepts of short- and long-term memory.(29, p. 187) The necessity of chunking information to store it, however, explains why cognitive structures rather than words or sentences are stored over a long term.

The second psychological concept is that of the schema, a concept that has excited cognitive psychologists recently.(32) Much of the information stored in long-term memory appears to be stored as schemata--large, complex units of knowledge that organize much of what people know about general categories of objects, classes of events, and types of people.

Schemata are broader pieces of knowledge than cognitive structures; they are sets of such structures. People retain information from reading or listening by encoding it from short- to

long-term memory as a cognitive structure. In long-term memory, however, they organize those cognitive structures into broader, more comprehensive schemata.

Schemata are organized, but they can be organized in different ways. Some schemata are organized in a hierarchical structure.(33) In other schemata, the items fit together simply because they have a "family resemblance."(5, pp. 133-137) Although all schemata are more complex than cognitive structures, some are more complex than others.(34)

Schemata help people to assimilate new information; people make sense of information by fitting it into an existing schema. Scientists can read and understand complex journal articles, for example, because they have a schema--a scientific theory--into which they can assimilate the information. Nonscientists cannot assimilate the information in the article, however, because they lack an appropriate schema.

Schemata also can distort information because people sometimes make sense of information by fitting it into an inappropriate schema. At the same time, schemata are dynamic; they grow and change to accomodate new information, much as scientific theories change to accomodate new research.

The third relevant concept from cognitive psychology is that of the image. Images are not mental pictures, as originally envisioned by John Locke. Rather they are sensory-spatial analogs of what people "see" in the world.(5, pp. 63-93) Images are less crisp and more malleable than are photographs. Images capture spatial relationships, although not in exact detail. Language, in contrast,

is organized sequentially.

For a time, cognitive psychologists accepted Paivio's 'dual code theory'--that information is retained in memory either visually or verbally.(35) Now they believe that both visual images and language symbols are retained in long-term memory as abstract propositions. People hold symbols and images in short-term memory but process them into long-term memory in the same way. The important implication of this single-processing mode for a communication theory is that the processing of visual information--such as photographs and graphics--follows the same rules as the processing of language. Thus, our axiomatic theory should apply to visual composition as well as to writing.

Anderson explained why the dual code hypothesis seems plausible on the surface, in terms similar to those used by philosophers when they claim that people cannot have access to cognition without using language. Anderson added images to language:

> One might ask, however, why, if the abstract representation is the dominant one, we have so strong an introspective awareness of imagery and verbal codes but hardly any introspective awareness of an abstract code. This discrepancy might be due to the fact that when we recall information from long-term memory we tend to verbalize it or construct an image of it. Thus, even if the long-term knowledge is abstract, we represent it to ourselves in our consciousness in more concrete terms.(5, p. 122)

Most of the concepts of our axiomatic theory come from philosophy and psychology of language. Before presenting that theory, however, we will briefly examine some related fields in which research supports the theories we have discussed thus far.

Reading Research

> The reason our children are such poor readers is that we spend too much time teaching them to read...
>
> The real problem, as reflected in standardized tests, national assessments of education and other measures of pupil achievement, is not the thing we normally think of when we talk about reading: learning to pronouce words and to understand their meanings. The problem is in reading comprehension: teaching children to think about what they read.(36)

This quote, by Washington Post columnist William Raspberry, summarizes well current knowledge of reading processes and shows its connection to the writing theory we are developing. Reading researchers have learned that good readers do 'contextual reading.'(37) Good readers can reorder their thoughts to explain what they have read; poor readers cannot. Poor readers pronounce each word but do not understand what they are reading--i. e., they do not use the words to develop a cognitive structure. In contrast, good readers who do not understand what they are reading stop and reread or seek help until they understand.

Reading researchers have found that practice in listening, writing, and speaking is important in the teaching of reading.(38) Thus, we find confirmation in reading research of the basic assumption of our axiomatic theory: language and thought are independent; language is a tool used to produce and explain cognitive structures. To learn to read, a student must learn to think--to use language to form cognitive structures. To learn to write, a student must learn to choose words that help to explain a cognitive structure.

Social Psychology

In the 1930s, Gordon Allport called the concept of attitude

the central topic of social psychology.(39) For many years, attitude was also the central topic of communication research; the standard communication study was designed to learn the conditions under which a persuasive message would bring about attitude change. Both social psychology and communication research have experienced a cognitive revolution in recent years, however, that places the concept of attitude into a more useful theoretical framework.

In the past, attitude theorists typically ignored the content of a message and the thoughts that pass through a person's mind after he or she receives a message and before he or she makes an evaluation. Now, a new school of 'cognitive response' theorists views the receiver of a persuasive message as 'an active information processor who manipulates, elaborates, and integrates the information as it is received.'(40) Generally, cognitive response research shows that a message that produces more positive than negative thoughts will result in attitude change; one that produces more negative thoughts will not. Research on counterarguing, for example, shows that a message that stimulates a person to think of opposing ideas will not be persuasive.(41)

Attitude theorists traditionally have included both cognition and affect (evaluation of cognitions) in their definitions of attitude.(42) Recently, many attitude theorists have called the cognitive component 'beliefs' and the affective component 'evaluation of beliefs.' They then define attitude as the product of the two. Recently, attitude theorists also have adopted the cognitive concept of schema and defined it as a complex set of interrelated beliefs and evaluations. Because, in their definition, attitudes are the products of beliefs and evaluations, schemata represent 'little

more than a complex of interrelated attitudes.'(43)

Although Fiske and Linville argued that a schema is 'a self-sufficient cognitive construct that does not require affect,'(44) other social psychologists generally seem unable to conceive of a cognition that does not have a valence attached to it--an evaluation. Like Fiske and Linville, we begin with the presupposition that human thought can take place without an evaluation attached--especially scientific thought. Thus, with philosophers of language, we assume that people communicate to accomplish illocutionary acts--use words and symbols to help people construct ideas. Like the philosophers, we assume that perlocutionary acts--changes in evaluation of ideas--also may result from communication. But, we add that changes in evaluation result from the deliberation of the message recipient and not from the force of the language. The realization that people deliberate about persuasive messages, we believe, represents the major contribution of the cognitive response school of attitude change.

Stamm and Grunig, for example, have found that people can hold seemingly opposed cognitions at the same time--what they call 'hedging'--and that people do not have to 'wedge' one cognition out at the expense of a contradictory one.(45, 46) In other words, people can interrelate cognitive structures into a single schema even though an outside observer--such as an attitude researcher--believes one of the cognitive structures has a negative valence and the other a positive valence.

We agree that people can--but do not have to--evaluate their cognitive structures and schemata. Generally, people evaluate their ideas when they must decide upon an action--what some social psy-

chologists call 'self-generated attitude change.'(47) But, in contrast to most definitions of attitude as enduring, cross-situational evaluations, our research shows that evaluations can be specific to one situation or carried from one situation to another.(42, pp. 171-173) (For example, I may decide one Saturday evening to see a Jane Fonda movie because it is the best one showing that night but not use that decision again to decide whether to see another Jane Fonda movie. On the other hand, I may dislike Fonda's beliefs about nuclear power so much that I refuse to see any of her movies.) We call the situational evaluation a situational attitude and the cross-situational evaluation a referent criterion.

A second important contribution of cognitive theories of attitude is the finding that people can use what we call a referent criterion to determine what information they seek and retain as cognitive structures, in much the same way as they use schemata to frame the seeking, interpretation, and storage of information.(48) But we emphasize that cognitive and attitudinal framing of information can be separated. Both represent selective communication behavior, but communication and cognition framed by schemata are more "open-minded" than communication and cognition framed by attitudinal referent criteria. Science communication, we believe, more often is framed by schemata than by attitudes.

Information Theory

In 1948, Shannon introduced the concepts of entropy and redundancy in a classic paper titled the 'Mathematical Theory of Communication.'(49) Entropy, a concept Shannon borrowed from the physical sciences, represents the randomness of the elements of a message--thus, its information content. Entropy is greatest when

the probability of occurrence of each message element is equal--for example, when the next word of a passage could be any word and not be predicted by the previous word.

Redundancy is inversely related to entropy. It is a measure of the organization or patterning of message elements, organization that makes it possible to predict the rest of a message after hearing part of it. Hsia, for example, has stated that "redundancy is probably the most effective means yet found to reduce equivocation and error in communication."(50)

Writing carries the most meaning in the fewest words when it contains no redundancy. Readers may not understand any of the message, however, if it does not relate to anything they know or have heard before--if it does not relate to their schemata. Thus, science writing may be totally unintelligible to nonscientist readers because all of the elements of the science message are new to them--the message is filled with maximum information. Science writers, therefore, use definitions, examples, analogies, metaphors, and parables to introduce redundancy into a message by relating the scientific topic to a schema familiar to a reader.

Micklos and Bishop found, for example, that readers were confused less often while reading a science article after the authors increased the redundancy in the article.(51) Redundancy also increases the likelihood that a reader will retain a message in long-term memory, because, as reported by Anderson, the information people commit to memory is elaborated with redundant information.(5, pp. 192-195) The redundancy makes it easier for people to recall information because it is connected to several schemata. Putting redundancy into writing, therefore, provides an important

means of improving the likelihood that writing will produce a cognitive structure that people can recognize and store.

Rhetoric and Composition

Most of the classical principles of rhetoric and composition closely resemble the principles of psychology and philosophy we have reviewed. D'Angelo, an English professor, found great similarity between the organizational patterns of schemata and both Aristotle's classic topoi (lines of argument or methods or organizing discourse) and the paradigms (patterns of organizing an essay) of 19th century composition theory.(52) According to D'Angelo, topoi are "abstract and analytic, independent of the particular subject matter from which they derive."(52, p. 10) Paradigms, he added, "represent global patterns that recur from one essay to another...writers can use the same paradigm and write completely different essays with it."(52, p. 15) Both passages support our premise that language is a tool that resembles the ideas it communicates.

Topoi, D'Angelo concluded, "facilitate the retrieval of information,...help the writer to control the development of a piece of writing,...and aid the reader to follow the writer's ideas more easily."(52, p. 21) In discussing cognitive psychology, we learned that people can convert writing to cognitive structures more readily if they perceive a pattern of organization in that writing. Classical patterns of rhetoric and composition seem to provide the tools writers need to provide that organization.

Support can also be found in rhetorical theory for the assumption that cognition is more than words. Rhetorical theorists, following Aristotle, argue that most human communication is

enthymematic.(53) That means that people use Aristotle's enthymemes--syllogisms in which one or more of the premises is implicit--when they communicate. Enthymematic communication fits with the psychological principle that the meaning of discourse is more than the sum of the parts, and that the person processing symbols must fill in the meaning.

Jamieson, similarly, has argued that phrases such as "War to Win All Wars" or "Nothing to fear but fear itself" are examples of the classical rhetorical concept of synecdoche--phrases that connote much more meaning than the meaning apparent from the phrase itself.(54) Generally, these phrases convey all of the meaning of a cognitive schema when a communicator uses them to communicate to someone who possesses the schema. Thus, they are powerful communication devices. In science, for example, "E=MC 2" can evoke a complex schema for a reader familiar with relativity theory as can "behavioralism" for someone familiar with psychology.

Philosophy of Science

Science writers have a particularly difficult task because they must choose language that is familiar to their readers when they attempt to explain a complex scientific idea that is unfamiliar to their readers. Because language is a tool that fits particular cognitive structures or schemata, science writers may not be able to use ordinary language to represent or to communicate scientific ideas. Scientists can represent or communicate scientific ideas more easily because they have developed a specialized language that fits their cognitions better than ordinary language--a language that nonscientists generally call "jargon."

Philosophers of science have argued for centuries about the

nature of a theory. The logical positivists essentially argued in favor of the linguistic relativity hypothesis. They argued that a theory consists of the language in which the theory is written. Then, they argued that a theory can be shown to be logically meaningful if that language follows linguistic rules of logic and empirically meaningful if the language is connected to operational measures through correspondence rules.(55) By rigorously controlling the syntactics of theoretical language, logical positivists believed, they could also provide rigorous controls on the cognitive significance of theories.

Now philosphers of science have abandoned logical positivism's syntactic view of theory in favor of a semantic view--a theory almost identical to the theories of cognitive psychology we have examined. In the semantic view of theory, theories are essentially ideas that provide a model for the words, mathematics, schematic diagrams, or other symbol systems scientists use to represent and communicate those ideas.(55, pp. 221-230, 706-716)

Scientific theories vary in their complexity, however. Some simply consist of parameters or variables that provide an abstract replica of observable "phenomenal systems." Such theories resemble the propositional networks that we have called cognitive structures. Other theories are deeper and more powerful; they are complex schemata that connect and explain simpler propositional theories.(56, 57)

As a result, the more important and powerful scientific theories are more difficult to write about than the less abstract and powerful theories. Science writers may not be able to write about some of the more powerful theories. Or, they may be able to

use ordinary language to gain a partial understanding of a scientific theory--probably by making an imperfect fit into an analogous schema held by the consumer of scientific information.

Grunig's Theory of Communication Behavior

At the beginning of this paper, we stated that the language theory to be developed would provide a missing link in Grunig's behavioral theory of science communication. Several concepts from that theory connect it to the theory of writing.

Grunig bases his theory on the equililibrium or order assumption of general systems theory.(58) According to that theory, systems maintain an equilibrium internally and with their environment. Systems may be living or nonliving, but a theory of human communication applies only to such living human systems as individuals, organizations, communities, publics, or societies.(59) A theory of cognition and writing, in addition, applies only to the individual system level.

Grunig defines behavior of any of these human systems as a movement, action, or activity. He defines communication as one kind of behavior, an illocutionary act in which individuals or other human systems move words or other symbols to one another. Grunig theorizes that individuals begin to plan new behaviors when they perceive disorder either (1) in the system or (2) between the system and its environment--what he calls problem recognition.(1, p. 179)

When external disorder occurs, people engage in communication behavior to help choose the noncommunication behaviors that seem most likely to restore order with the environment, behaviors such as renting the best apartment, selecting an appropriate university

major, or selecting the best scientific theory.

For individuals, "disorder in the system" means cognitive disorder. People may not have an ordered cognitive structure, or a new cognitive structure produced by a message may not fit with existing schemata. Internal disorder, like external disorder, motivates people to communicate (60)--i.e., to move symbols in or out of memory to help them organize their cognitions--even though people may be able to integrate and retain information better when it fits into their existing schemata. The ideal speech or piece of writing, therefore, is one that helps people resolve internal disorder by connecting the new cognitive structure to existing schemata (i.e., a message with just the right amount of redundancy).

In addition to the proposition that perceived disorder motivates communication behavior, Grunig's behavioral theory contains a second link to our language theory--Grunig's concept that communication behavior may be either active or passive. Passively communicating people process information that comes to them without much effort on their part--e.g., while scanning a newspaper or listening to a news broadcast with no particular story in mind. Actively communicating people seek out information they need to resolve a disorder that actually involves them. According to Grunig, the higher people's perceived level of involvement in a situation the more actively they communicate about that situation.

For example, a person with a disease--an external disorder--will actively seek information about the disease from doctors, informational brochures, or "hot-lines." A person who does not have the disease may read about that disease passively when time permits but will not seek the information as actively as the person with

the disease. Similarly, a physicist will actively communicate to construct a theory that can integrate the three major forces in the universe--an internal disorder. A reader of a popular science magazine, who is not involved with research on the theory, may read a popular science article on the three forces but will not actively seek information about the topic as will the physicist.

The difference between active and passive communication affects the writer because clarity and organization of writing are more important for the passive reader than for the active reader. Active readers help the writer by rereading words they do not understand and by reorganizing their thoughts to make sense of what they read. Clear, organized writing that uses analogies to insert redundancy helps the active reader as well as the passive reader.(61) But the passive reader will not help the writer. If words have no meaning or writing has no organization, the passive reader's attention will drift or he or she may stop reading altogether.(62)

The third link between our language theory and Grunig's behavioral theory is his theory of communication effects. In most research on science writing, the criterion used to determine effective writing has been either message recall or attitude change. Grunig has added a cognitive variable to these two.(42) Using terms borrowed from McLeod and Chaffee (63), he defines message recall as 'accuracy,' formation of a cognitive structure as 'understanding,' and making the evaluation that the writer desires as 'agreement.' In developing our writing theory, therefore, we maintain that good writing produces understanding, a variable seldom measured in previous research on science writing.

THE AXIOMATIC THEORY

At this point, the general nature of our theory of cognition and writing should be apparent. The next step in this paper, then, is to state the theory formally in axiomatic form--a form that makes the theory easier to test empirically and a form that makes the theory more useful for writing instruction. In presenting our axiomatic theory, we begin by defining key concepts; generally these concepts come from the theories we have just reviewed. Then we state the basic premises of the theory--the presuppositions that cannot be tested directly. Finally, we state testable propositions that follow logically from the presuppositions.

Definitions

The first concept comes directly from Grunig's theory of communication and its definition of behavior.

1. BEHAVIOR. Doing or performing something: a movement, an action, or an activity.

The next three concepts are derived from the cognitive psychology theory that the substance of short-term memory is verbal and visual representations (5, p. 117) and the classification of these representations in the philosophy of language.(9, pp. 50-61)

2. SYMBOL SYSTEM. A set of interrelated tools used to make sequential representations of cognitive structures in short-term memory and to communicate about cognitive structures with other people. Symbols include words, mathematical symbols, musical symbols, iconic models, flow charts, chemical symbols, and nonverbal cues.

3. LANGUAGE. An equivalent term for a symbol system.

4. IMAGE. A sensory analog of physical objects and processes use to make spatial representations in short-term memory. As analogs, images are not mental pictures.

The next concept is central to our theory: the cognitive psychology definition of the nature of ideas.

5. COGNITIVE STRUCTURES. The abstract patterns in long-term memory that underlie the verbal and visual representations in short-term memory. Cognitive structures contain elements such as subjects or agents, objects, attributes, and recipients of actions, which are connected by spatial, temporal, or logical rules.

Our definition of communication, then, combines elements of the previous four definitions with Grunig's systems' definition of communication.

6. COMMUNICATION. A behavior in which two or more persons move symbols from one to another in an attempt to construct a common cognitive structure or to reconstruct a cognitive structure already present in one person's mind in the minds of one or more other people. The generation of symbols to represent cognitive structures and the attempt to comprehend the cognitive structures represented by symbols are both communication behaviors.

Then, we introduce the new and central concept of cognitive and social psychology.

7. SCHEMATA. Large, complex units of knowledge that organize, in long-term memory, much of what people know about general categories of objects, classes of events, and types of people. Schemata are larger and more complex than cognitive structures, which encode smaller units of knowledge that are derived from the verbal and visual representations in short-term memory. Items in schemata may be organized in a hierarchy or through family resemblance patterns.

We then define attitude and two specific kinds of attitudes.

8. ATTITUDE. An evaluation of a cognition that has implications for behavior.

9. REFERENT CRITERION. An attitude developed to resolve one situation that is applied in new situations.

10. SITUATIONAL ATTITUDE. An evaluation used in a single situation.

Next, we present our definitions of communication effects that were taken from the coorientation model.

11. ACCURACY. A communication effect in which one person has successfully reconstructed the other person's cognitive structure.

12. UNDERSTANDING. A communication effect in which two people have

constructed a common cognitive structure.

13. AGREEMENT. A communication effect in which two people make the same evaluation based upon either a referent criterion or a situational attitude.

We define the classical term persuasion, not as accomplishing any communication effect, but as follows:

14. PERSUASION. Change in attitude, behavior, or both as a result of communication.

Finally, we include Grunig's concept of involvement, which he uses to explain the presence of active versus passive communication behavior.

15. LEVEL OF INVOLVEMENT. The extent to which a person perceives a connection between himself or herself and a situation.

Premises

The first premise of our axiomatic theory is also the basic premises of Grunig's systems theory of communication behavior; thus, it connects this language theory to that communication behavior theory. the second premise states the assumption that human thought follows the same law as human behavior.

1. Human behavior begins when the person perceives disorder in the environment; behavior then is directed toward the construction of order.

2. The purpose of thought is to construct ordered cognitions that a person uses to direct ordered behavior.

The third and fourth premises state presuppostions about the relationship between language and cognition tht are accepted by most philosophers and psychologists of language.

3. The language a person uses to communicate depends on the cognitive structures the symbols represent. Cognitive structures do not depend on language, as the linguistic relativity hypothesis maintains. Symbol systems bear a strong resemblance to cognitive structures because the two have similar structures.

4. Some symbol systems will fit some cognitive structures and

schemata better than others.

The fifth premise, however, maintains that people can use communication to clarify their cognitive structures. As discussed in the section on psychology of language, cognition need not be complete before communication begins.

5. Thought will not always be complete before communication behavior begins. Speaking and writing often help the person to develop and clarify cognitive structures.

Next, we formalize the theories of psychology of language and philosophy of science in which we learned that cognitive schemata, scientific theories, and related symbol systems vary in complexity. Then, we formalize the relationship between existing schemata and communication.

6. Cognitive schemata vary in complexity, and the symbols systems used to represent the cognitive structures that make up those schemata also vary in complexity in direct relation to the complexity of the schemata.

7. Schemata may provide frames for processing information, understanding messages, and retaining messages in memory in situations in which the schemata are relevant.

We then state our assumption about the purpose of communication and the effects it can be expected to achieve.

8. The primary purpose of communication is to achieve accuracy and understanding, rather than to achieve agreement or change behavior--i.e., illocutionary acts take precedence over perlocutionary acts.

Social psychological research then provides the basis for two assumptions about the relationship between attitudes and cognition.

9. Attitudes originally develop from cognitions, but a person may retain the attitude and forget the cognitions from which it developed.

10. Referent criteria (cross-situational attitudes) may provide frames for cognitions in situations in which the referent criteria are relevant.

Finally, we summarize cognitive research that shows that

images and verbal symbol systems relate to cognitive structures in the same way.

11. Visual communication, which produces sensory spatial images, produce cognitive structures in the same way as spoken or written communication and follows the same principles of effectiveness.

Propositions

Having stated our basic definitions and premises, we turn to the 11 principles that are the heart of the theory. These principles can be subjected to empirical test; and, as we will show, they subsume most writing rules.

The first principle follows logically from the premise that the purpose of communication is form cognitive structures. If that premise is correct, then it follows that people will be able to develop one cognitive structure at a time better than several structures. Thus, we state a general proposition about cognition and a corollary, which follows logically from the principle, about the effectiveness of communication related to cognitions.

1. THE SINGULARITY PRINCIPLE. People find it easier to construct or reconstuct one cognitive structure at a time than two or more cognitive structures.

> Corollary 1. The greater the number of cognitions communicated at one time, the less often accuracy and understanding will occur.

The utility of Corollary 1 can be seen in Odell and Merrill's statement that words of a language fit together like the pieces of a jigsaw puzzle.(12, p. 40) Most people find it much easier to fit pieces of one puzzle together at a time. Mix the pieces together from two or more puzzles and confusion mounts geometrically. Corollary 1, therefore, explains the value of such writing principles and devices as unity and coherence, topic sentences, and and organizational patterns. In visual communication, the corollary

explains why one should follow the principles of unity and simplicity in composing photographs and designing graphics, as well as the value of a center of attention.

At times, writers and visual communicators realize they must communicate more than one cognitive structure; they generally solve the problem by using transitions. Thus:

> Corollary 2. When more than one cognition must be communicated at a time, they should be separated and linked by transitional devices.

Receivers of messages, however, often impose their own singularity on messages they receive. Sometimes, self-imposed singularity helps achieve effective communication; sometimes it does not. Thus:

> Corollary 3. People use schemata or referent criteria as frames to achieve singularity of cognitions. These frames may hinder or help the achievement of accuracy or understanding, depending on the relevance of the schemata or referent criteria to the cognition being communicated.

It follows from this corollary that the writer must attempt to determine what schemata or referent criteria readers will have. If the schemata or referent criteria help the writer, he or she can make reference to them to achieve accuracy and understanding. If they hinder the writer, he or she must communicate to help the reader form a new and more relevant schema or referent criterion.

In our second principle, we explain the editor's concern for wordiness and verbosity, as well as the writing teacher's comment, 'that's redundant' or 'you've already said that.' If the purpose of writing--and communication in general--is to use words to help people construct ideas, then it follows that using too many words forces the reader to process and make sense of more words than are

necessary to get the idea across. Anderson states a similar principle as the 'maxim of quantity': 'Be as informative as required, but not more informative than is required.'(5, p. 444) In general words, should not be used when they add nothing to meaning:

2. THE PARSIMONY PRINCIPLE. The fewer symbols used to communicate cognitive structures of the same complexity, the more efficiently the person receiving the symbols will be able to reconstruct the cognition.

Writing teachers frown on many writing practices that violate the parsimony principle. For example, passive voice usually takes more words than active voice to say the same thing. Complex and run-on sentences also waste words.

However, passive voice also disguises one key part of the proposition underlying a sentence: the subject. Similarly, complex and run-on sentences disguise the deeper cognitive propositions they represent. Verbs turned into nouns hide the relation between subject and object. Writers who violate the parsimony principle, in other words, often do not write clearly and thus violate a third principle, a clarity principle. In addition, too much parsimony can sacrifice clarity. For example, stacking of modifiers--such as 'the behavioral psychological experimental manipulative technique'--achieve parsimony by eliminating prepositions. But stacked modifiers sacrifice clarity by disguising the relationship between the modifiers.

To determine what it means to write clearly, however, requires some explanation. The nature of clarity may be found in the ordinary language tradition in philosophy, which stresses that the same words or different combinations of the same words can be used to accomplish different illocutionary acts--i.e., to help a recipient of the words develop different cognitive structures. Thus, the

writer must choose words with great care to help a reader construct the desired cognitive structure. Cognitive psychologists, like language philosophers recognize clarity as an important element in successful communication.(5, p. 445) Writers seem to write clearly, then, when they choose words that correspond to the elements of deeper cognitive propositions: subjects, agents, objects, attributes, and recipients.

In addition, as we saw above, theories of cognitive psychology show that people remember messages better when they follow an organizational rule that is apparent to the reader. Anderson, for example, recommended that writers outline or organize their cognitions before they write or as they write.(5, pp. 454-455) As we saw in the section on rhetoric and composition, Aristotle's classical topoi and 19th century rules of composition provide the necessary organizational patterns. The necessity of organizing writing corresponds to models of cognitive structures that link the elements of propositions--subjects, agents, objects, attributes, and recipients--with rules such as spatial, time, or formal logical rules. The two elements of clarity, words and organization, therefore are incorporated in our third principle:

3. THE CLARITY PRINCIPLE. Communication will achieve accuracy and understanding more often when recipients of messages receive symbols that correspond to each element of a cognitive structure or network of structures and the organizational pattern of the messages follows a rule that is apparent to the recipient.

Information theory showed the value of redundancy of writing and suggests a fourth principle. Redundancy does not mean to use symbols that convey no new meaning, which would be a violation of the parsimony principle. Rather redundancy means to use different symbols to help readers add elements to an emerging cognitive

structure, elements which other symbols did not help them to grasp. Or, it means to connect statements that convey new meaning--what Anderson calls assertions--to statements that relate to existing schemata--what Anderson calls suppositions.(5, p. 416).

4. THE REDUNDANCY PRINCIPLE. The use of different symbols within the same symbol system or the use of different symbol systems to communicate a cognitive structure increases the frequency with which accuracy and understanding are achieved.

The first corollary of this principle explicates when redundancy has its greatest value.

> Corollary 1. Redundancy will increase the frequency of accuracy and understanding most when the cognitive structure to be communicated or the schema to which it is connected is complex.

After a point, redundancy will no longer be effective. Baltimore Sun science writer Jon Franklin, for example, has what he calls a rule of three. Three examples or analogies are useful. Any more are too many.(64) Thus, a second corollary:

> Corollary 2. Redundancy beyond the level indicated by the complexity of the cognitive structure or schema will not enhance the frequency of accuracy and understanding; instead it may cause the recipient of the message to lose interest in the message.

The third corollary shows the relationship of several rhetorical devices to redundancy.

> Corollary 3. Rhetorical devices such as definition, analogy, metaphor, example, or parable increase the frequency of accuracy and understanding because they are redundant to familiar schemata.

Next, we deal with the adjustment writers and other communicators must make when cogntive complexity increases.

5. THE COMPLEXITY PRINCIPLE. The greater the complexity of a cognitive structure or of the schema to which the structure is connected the greater the difficulty of communicating the cognition to someone without an appropriate schema.

> Corollary 1. A communicator must understand a complex cognition before he or she can

communicate it to someone else.

Corollary 2. To communicate a complex cognition to a person without an appropriate schema to frame the the cognition, the cognition must be related to a schema familiar to that person and in a symbol system appropriate to the familiar schema.

Grunig's theory of communication behavior maintained that readers or other recipients of communication who do not perceive an involvement in the situation to which a message relates will be passive communicators who will do little to help the communicator in forming cognitions from messages received. Active message recipients, in contrast, work with the symbols they receive until the meaning becomes clear. For low involvement readers, then, the next principle holds.

6. THE LOW INVOLVEMENT PRINCIPLE. The lower a person's level of involvement in a issue, the greater the effect of Principles 1 to 5 in achieving accuracy and understanding.

Earlier, we said that writing and speaking frequently help the writer or speaker to organize his or her cognitions. Anderson, reporting on cognitive research, said, for example that "speakers usually plan their meanings as they generate their sentences. Many of the awkward or grammatically deviant sentences that occur in discourse reflect the conflicting demands of these two ongoing processes of construction and transformation."(5, p. 453) The next principle, therefore, follows logically from this research; it also subsumes the advice frequently given to writers that "good writing is rewritten not written."

7. THE RECONSTRUCTION PRINCIPLE. The greater the extent to which communication is used to help construct cognitions, the more the message must be reconstructed, using the five previous principles, if accuracy and understanding are to be achieved.

Micklos and Bishop, as discussed in the section on information theory, found that writers could reduce reader confusion by ident-

ifying places in a piece of writing that confused readers and then inserting redundant information at those points.(51) Feedback from readers, in other words can improve writing. Thus, an eighth principle.

8. THE FEEDBACK PRINCIPLE. Messages that are produced after a communicator has received feedback from a previous communicative effort will result in greater accuracy and understanding than the first message.

In our discussion of rhetoric, we discussed the reader or listener's role in supplying meaning beyond that carried by words or sentences. Synedochic phrases, in particular, can convey great meaning.(54) The ninth principle captures the idea of synecdoche.

9. THE SYNECDOCHIC PRINCIPLE. Symbols that suggest a familiar schema to the recipient of a message evoke complex meaning that is not apparent from the phrase alone to someone who does not have a similar schema.

Frequently, individual words or phrases may evoke a schema of which the writer or speaker is not aware. For example, the term 'girls' rather than 'women' or the generic 'he' may evoke a schematic response in women. Thus, there is a negative corollary to the synecdochic principle.

Corollary 1. When the communicator does not intend to evoke a a schematic response, the synecdochic phrase will decrease the frequency of accuracy and understanding and may result in an unintended emotional response.

The last two principles and their corollaries capture the relationships between cognitions and attitudes that have been conceptualized by social psychologists.

10. THE PERSUASION PRINCIPLE. The greater the number of cognitive structures with implications for attitudes and behavior favored by the persuasive communicator, the greater the likelihood of favorable attitudes and behavior.

Corollary 1. The person who holds a preponderance of favorable or unfavorable cognitions (wedges) will be likely to form an attitude and engage in behavior.

Corollary 2. The person who holds a relatively equal number of of favorable and unfavorable cognitions (hedges) will not be likely to form an attitude and engage in behavior.

11. THE ATTITUDE FRAME PRINCIPLE. When a cross-situational attitude--a referent criterion--provides a frame for thought, it is difficult to achieve accuracy and understanding of cognitive structures whose implications for behavior do not fit within that frame.

Corollary 1. Attitudes that frame thought stimulate counterarguing that, in turn, makes the construction of cognitive structures with implications for behavior outside the frame difficult.

EXPLORATORY RESEARCH

Thus far in this paper we have reviewed theory and research in several language-related disciplines and then have derived an axiomatic theory of cognition and writing from that research. By following that course, we should have established that the theory can be supported by extensive research in the behavioral sciences and the humanities. Nevertheless, a great deal of additional research will be needed to confirm and improve the theory. Indeed, we believe the axiomatic theory will provide the framework for a long-term program of research. That research has begun, and in this section we present some of the exploratory research done to date.

To measure the cognitive effects of writing, researchers must have an instrument that allows them to observe what is happening in people's minds as they read. Most previous empirical studies of writing have measured recall of writing passages.(1, p. 186) Generally, however, recall tests measure whether people remember words and not whether they have constructed a cognition. Other studies have used measures of attitude change to test the effect of writ-

ing. Our theory maintains that attitude change is not the principal effect of communication; thus a measure of attitude is not appropriate.

We have found Carter's signaled stopping technique to be useful in observing cognitive processes.(65) With that technique, experimental subjects are instructed to read through a passage and to pay attention to the points at which they stop while reading. They are told to place a slash mark at each point in the passage where they feel like stopping. People stop when they cannot process words into a cognitive structure, when they need time to form that cognitive structure, when they get a structure and want to think about its implications, or because they agree or disagree with an evaluation or evaluative implication of a cognition. The experimenter provides subjects with a coding scheme that they can use to explain why they stopped. In the last studies, we have instructed subjects to use the following reasons for stopping.

C--Because of confusion:	You stop or pause in reading because you feel you have lost the idea the writer is trying to communicate.
R--To reread:	You stop because you have lost track of the idea but you can get back on track by reading a passage again.
?--To ask a question:	You stop because you feel that if you could just ask the writer a question it would help you to understand the idea he or she is trying to communicate.
T--To think about the idea:	You stop to mull over what you have read and try to put it all together.
U--Because you understand:	You stop because you do understand the writer's main idea and want to "let it sink in."

A--To agree:	You agree with what the writer said.
D--To disagree:	You disagree with what the writer said

Write in any other reason for stopping.

For the last section of this paper, therefore, we will examine studies that have used this technique to test our axiomatic principles.

Early Studies

Several years ago, two University of Maryland studies confirmed the redundancy principle, but only for active readers. Grunig used the stopping technique to test the effect of analogies, examples, and parables used in articles on economics.(61) The major dependent variable measured was stops for thinking, which Grunig considered to be a logical antecedent to forming a cognitive structure. The results showed that analogies and examples stimulated thinking for active but not for passive readers, confirming that passive readers do little to help the writer. Examples reduced thinking for active readers, however, probably because they divert readers' attention from the central cognitive pattern being developed by the writer.

Bartholomew replicated this study to test the effect of analogies used by Isaac Asimov in his book "Understanding Physics."(66) Again, the analogies stimulated thinking for active readers (physics students) but not for the passive readers (Journalism students).

Patrick examined the stops of subjects who read a short report that she had used as a particularly bad example of writing in classes she taught at the U. S. General Accounting Office.(67) She

rewrote the report--about an Army Corps of Engineers dam--following the parsimony, clarity, and redundancy principles and found that subjects stopped significantly fewer times to reread than did subjects who read the original version--a confirmation of the principles. There were no significant differences in the other reasons for stopping, however.

Metaphors and Analogies in a Land Use Brochure

In 1982, Schneider did a critical analysis of a brochure produced by the National Agricultural Lands Study in Washington, D.C., that was written to create awareness of the loss of prime farm land in the United States to urban development.(68) The brochure was highly acclaimed: it received the highest award of the professional association, Agricultural Communicators in Education and was reprinted in magazines and newspapers throughout the country.

Schneider's analysis showed the metaphor to be the principal figure of speech used in the brochure. In particular, the author of the brochure, Shirley Fields, used a war metaphor to gain understanding of the urgency and severity of the loss of farm land. Fields hoped to marshall a volunteer amry--concerned individuals--to defeat the enemy--land developers. If the valiant farmers, ranchers, scholars and environmentalists failed in their heroic attempt, Fields predicted, a "wake of urban sprawl" would result, not unlike the devastation an occupied country experiences after war.

Writers who use metaphors are applying the redundancy principle. At the same time, however, they violate the parsimony principle because they must use more words to get the idea across. Woelfel and Fink, for example, consider the metaphor to be inherently

uneconomical and time consuming (it sacrifices parsimony)--but necessary for understanding (it provides redundancy).(25) Our primary research question in this study, therefore, was to determine whether the loss of parsimony would be offset by the advantages of redundancy.

We rewrote a portion of the agricultural lands brochure to eliminate the metaphors, reducing its length from 93 lines to 61 lines and thus achieving parsimony. Two groups of students--in public relations classes--read the original and revised versions and did the stopping exercise. Table 1 shows the results.

TABLE 1

Number of Stops and Reasons for Stopping While Reading An Agricultural Lands Brochure With and Without Metaphors

Reason for Stopping	Metaphors Mean	Stand. Dev.	No Metaphors Mean	Stand. Dev.	t
Think	2.50	4.31	1.25	1.57	1.08
Understand	0.14	0.36	0.25	0.77	0.47
Reread	2.14	1.96	1.69	1.82	0.66
Confused	0.79	1.12	1.06	1.00	0.72
Ask Question	0.14	0.53	0.44	0.73	1.25
Agree	0.43	0.85	0.25	0.58	0.68
Disagree	(Only one stop in both conditions)				
Other Stops	0.78	1.42	0.94	1.39	0.30
TOTAL STOPS	7.00	5.02	5.88	2.19	0.66
N	14		16		

*p < .05
**p < .01

The data in Table 1 show no significant differences between the two versions of the farm lands brochure, although there are more total stops, more stops to think, and more stops to reread when the metaphors were used. The difference in stops to think was

significant at the .30 level, however, and that difference and the difference in total stops might have been significant with a larger sample size. Most of the additional stops in the version with metaphors occurred at the metaphors themselves, and the most frequent reason for stopping there was to reread. Generally, then, these results support what we would expect to be the effect of the two principles. Readers must work more and stop more often when parsimony declines. People do not understand metaphors immediately; they must reread them. In addition, the increased redundancy makes people think more about what they are reading.

Other data in the study showed that the brochure had little attitudinal effect, even though the war metaphor is supposed to elicit value responses from readers.(69) The data in Table 1 show that very few readers stopped to agree or disagree while reading the two versions of the brochure. In addition, items on a before and after questionnaire showed that reading either version of the brochure did not make the subjects think the farm land problem was more serious. In fact, after reading the brochure another question showed that the subjects were somewhat less likely--although not significantly less likely--to think that loss of farm land could be disastrous for the United States.

Results from two knowledge questions also showed that subjects gained little knowledge from reading either version of the brochure. Most of these students came from urban backgrounds and, as a result, had a low level of problem recognition and a moderate level of perceived involvement for the farm land problem. Thus, Grunig's theory seems to hold: the students had little reason to want to read the brochure, and thus they gained little knowledge

from it.

Examples in a Story About Student Use of Alcohol

A second study tested the redundancy and parsimony principles in nearly the same way as the farm lands brochure study. In this study, however, we used examples to produce redundancy whereas the writer of the brochure used metaphors in the first study.

We wrote one version of a health story about problems of students using alcohol in which major points were illustrated with examples. We then prepared a second version of the story with the examples removed. Again, the second version was shorter, preserving parsimony. Students in several beginning writing, editing, and public relations courses served as experimental subjects.

TABLE 2

Number of Stops and Reasons for Stopping While Reading A Health Story About Alcohol Abuse with and without Examples

Reason for Stopping	Examples Mean	Examples Stand. Dev.	No Examples Mean	No Examples Stand. Dev.	t
Think	2.26	2.30	1.26	1.67	2.24*
Understand	3.79	5.50	3.49	6.00	0.23
Reread	2.67	2.19	2.13	2.12	1.12
Confused	1.05	2.04	0.49	0.82	1.60
Ask Question	0.71	1.57	0.95	1.69	0.65
TOTAL STOPS	10.48	8.27	8.31	9.50	1.10
N	42		39		

*p < .05
**p < .01

Table 2 shows the results. Subjects who read the version of the story with examples stopped more often and stopped more often for every reason other than to ask a question. Both groups of stu-

dents stopped most often to say they understood what they were reading, perhaps because the story was not a complex one. As with the farmlands brochure, however, the examples forced subjects to stop significantly more often to reread. Again, the results show that loss of parsimony forces readers to stop more often, but they also show that added redundancy forces readers to work more to help the writer get across the idea he or she is communicating.

TABLE 3

Mean Pre- and Post-Test Evaluations of the Extent to Which Use of Alcohol is "Troublesome" for Subjects and for Their Friends

	Troublesome for Self	Troublesome for Friends
Examples		
Pre-test	1.83	1.65
Post-test	1.95	2.00
t	1.71	3.15**
No Examples		
Pre-test	1.90	1.59
Post-test	1.95	1.64
t	0.82	0.81

*p < .05
**p < .01

(Scale = 1 - 4, in which a low score means alcohol use is "fun" and a high score that alcohol use is "troublesome.")

Although we did not include the agree and disagree stops in the second experiment, we did give subjects a before and answer scale that asked them to rate how troublesome a problem alcohol use was for them and, in a second question, for their friends. Table 3 shows that the story with examples succeeded in making subjects think alcohol was a more troublesome problem for their friends, although not for themselves. The examples, it seems, were about other

students; and, as the cognitive response principle states, the more subjects thought about people with alcohol problems the more troublesome the problem appeared to be for their friends. The subjects apparently did not identify themselves with the people in the examples.

Cognitive Responses to a Persuasive Article About Alcohol

In a study to test the persuasion principle, Debra Nelson, a master's student in journalism, and Daniel Ipes, a Ph.D. student in public communication at the University of Maryland, wrote a persuasive article designed to convince students that minimum age for drinking should be raised. If the persuasion principle holds, an article should change the evaluations of people who read it if the article produces cognitions with positive implications in the readers' minds.

Nelson and Ipes used the signaled stopping technique to monitor cognitive responses, and they used several before and after evaluative scales to measure attitude change. Fifty-six students in reporting classes served as subjects for the experiment. Table 4 shows that the most frequent stops were to agree, to show understanding, and to reread. The subjects, in other words, spent time rereading the article when necessary, understood what they read, and agreed with the writers more than they disagreed with them. Table 5 shows that subjects strongly believed highway fatalities were related to alcohol consumption before reading the story and believed so somewhat less after reading it. After reading the article, however, they were more likely to agree that raising the minimum drinking age would reduce highway fatalities and to favor a higher drinking age.

TABLE 4

Stops Reported by Subjects While Reading a Story Advocating a Higher Minimum Age for Consumption of Alcohol

Reason for Stopping	Mean	Standard Deviation
Confused	.625	.906
Reread	1.174	1.398
Ask question	.500	.831
Think	.857	1.495
Understand	1.071	1.346
Agree	1.196	1.494
Disagree	.464	.873

TABLE 5

Responses to Three Evaluative Questions Before and After Reading a Persuasive Article

	Mean	Standard Deviation	t
Highway fatalities are related to alcohol consumption(1)			
Pre-test	4.52	0.74	
Post-test	4.17	0.95	-.1.90*
Raising the minimum drinking age will reduce the number of highway fatalities(1)			
Pre-test	2.66	1.24	
Post-test	3.74	0.851	5.41**
The minimum age for consumption of all alcoholic beverages should be:(2)			
Pre-test	3.36	1.40	
Post-test	3.78	1.25	1.68*

*p < .05
**p < .01

(1) Scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.
(2) Scale: 4=21 years, 3=20 years, 2=19 years, 1=18 years.

The Nelson-Ipes study, therefore, supports the persuasion

principle, although it suggests that getting readers to understand an argument while reading it is more important than getting them to agree with the argument while it is being made.

IN CONCLUSION

In this article, we have made a major attempt to construct a scientific theory of writing using concepts from several of the behavioral sciences and humanities as building blocks. We have also presented research evidence to support portions of the theory. Many years of research will be necessary to thoroughly test and revise the theory, but we believe the theory already carries the accumulated empirical evidence gathered to support the behavioral science theories from which it was constructed. We also believe the theory already has great value for teaching writing--especially science writing. We believe, however, that the theory will have its greatest value if it stimulates other researchers to test, revise, and expand upon its axioms.

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